Temperature Signatures for Urban Soils of New York City

H. Mount, Soil Scientist, NSSC, NRCS, Lincoln, Nebraska

L. Hernandez, Soil Survey Project Leader, NRCS, Staten Island, New York

Figure 1. View of Lower Manhattan.

Figure 2. PVC Pipe Protects the Stow-Away Data Logger.

Figure 3. Chatfield Site in Central Park.

Figure 4. Chatfield Soil Profile.

Figure 5. Playground Site in Central Park.

Figure 6. Data Logger Installation.

Figure 7. Assuring that the Logger is Not Visible.

Figure 8. Greenbelt-like Soil Profile.

Figure 9. Sassafras Grows at the Valois Site.

Abstract

Soil temperature regimes, as used in the United States of America (USA) soil classification system, have precise seasonal and annual fluctuations. Soil temperature of urban soils in the USA is not well documented. Efforts to publish soil temperature data as part of a progressive soil survey has generally been unsuccessful. The process of collecting and analyzing large amounts of data has been simplified with the advent of automated data collection technology.

In 1996, the United States Department of Agriculture's Natural Resources Conservation Service enacted the Remote Soil Temperature Network. Projects were located across the continental USA, the Pacific, and Caribbean.

A project was established in New York City to document temperature of urban soils. Nine sites representing urban soils were selected across the five boroughs that make up the city. In each site, three temperature sensors were located at different depths to determine mean annual soil and air temperature. A total of 97,200 data points were collected during a period of two years. Mean annual soil and air temperatures were used to determine soil temperature regime of urban soils at each site.

Introduction & Objectives

Efforts to publish soil temperature data as part of a progressive soil survey within the Natural Resources Conservation Service for the U.S. Department of Agriculture has generally been unsuccessful in the past 100 years (NRCS Soil Climate Team, 1995). With the advent of automated data collection technology such as StowAway temperature loggers, the process of collecting and analyzing large amounts of data has been simplified.

Some of the parks in New York City have been soil surveyed and published without temperature data (Hernandez and Galbraith, 1997). Additional areas such as the Gateway National Park in Brooklyn are currently being mapped with a concerted interest in capturing the temperature signature of their anthropogenic soils. Consequently, the objectives for the New York City temperature study included: 1) measuring the daily air and soil temperature at four sites in New York City to incorporate information into future soil survey publications; 2) testing hypotheses on the conjectured temperature signature at each site; and 3) verifying the presence or absence of an exothermic effect of the Greatkills soil at a 22-ha landfill site in Latourette Park on Staten Island.

Study Area

New York City is the largest city in the USA and is home to eight million people. Its Manhattan skyline is one of the most recognized of any city in the world (Figure 1). Two soils in Manhattan's Central Park and two soils in Staten Island's Latourette Park were targeted for installation. Soil and ecosystem characteristics for each site are presented in Table 1 (Hernandez and Galbraith, 1997).

Methods & Materials

StowAway temperature loggers store 1,800 data points from periods ranging from 15 minutes to 360 days. Their certified temperature threshold is ±0.7°F (±0.4°C). Prior to installation of the four sites in New York City, StowAway temperature loggers were programmed to collect data every 4 hours and 48 minutes for 360 days. This frequency is the same as five times each day.

At each site, a 22-cm PVC pipe with a 9-cm diameter housed three StowAway temperature loggers and a desiccant pack to absorb excess moisture (Figure 2). Holes drilled in the PVC pipe allow 6-foot sensor leads to exit outside while the temperature loggers are protected from the weather elements. These PVC pipes were installed at four sites in the study area on June 26, 1997.

A hole was dug with a sharpshooter to a depth of 50 cm at each site. Site data was then collected and the soils were briefly examined to gather a taxonomic classification (Figures 3-4 and 9-12). Except for the playground area in Central Park (Figures 5-8), one temperature sensor lead was tied to a tree sapling to capture air temperature and was generally placed from 60 to 90 cm above the soil surface. Two soil temperature sensor leads were installed at each site -- one at the 10-cm soil depth and one at the 50-cm soil depth. Finally, the PVC pipe was buried at about 10 cm and covered with soil. The unvegetated playground in Central Park mandated a slightly different protocol. At that site, only soil temperature sensors could be installed and they were placed at 20 cm, 38 cm, and 50 cm to collect data.

After retrieving the temperature loggers, data were downloaded on July 8, 1998, in New York City. Once completed, the temperature signatures were examined for each of the sites. Electronic failure of three temperature loggers resulted in loss of some data in the study area; however, the nine operative loggers collected more than 16,000 readings during the first year alone. Temperature data were averaged by month for each of the sites and an annual mean was then determined and graphed using Microsoft Excel software (Figures 13-16). In addition to an annual mean, the Mean Summer Temperature (MST) and the Mean Winter Temperature (MWT) were calculated to access the seasonal variation at each of the sites.

Table 1. Soil and Ecosystem Characteristics of the Temperature Sites in New York City.

	NYC Site #1	NYC Site #2	NYC Site #3	NYC Site #4
Park Name	Central Park	Central Park	Latourette Park	Latourette Park
Ecosystem	Woods	Playground	Woods	60-yr-old landfill
Elevation	~12 m	~7 m	~6 m	~6 m
Slope	17%	1%	15%	2%
Aspect	340°	275°	280°	360°
GPS Lat.	N 40-47-41	N 40-47-22.1	N 40-34-23	N 40-34-13.65
GPS Long.	W 73-57-25	W 73-57-17.59	W 74-9-49	W 74-10-1.31
Soil Series	Chatfield (Fig. 4)	Greenbelt (Fig. 8)	Valois (Fig. 10)	Greatkills (Fig. 12)

Table 2. Monthly Temperature Averages for Two Sites in Central Park.

Month	Woods 10 cm (C)	Playground 20 cm (C)	Woods 50 cm (C)	Playground 38 cm (C)
Jan 98	4.14	4.24	5.24	4.94
Feb 98	3.82	4.66	4.48	5.07
Mar 98	5.38	7.21	5.32	7.10
Apr 98	9.72	13.30	9.02	12.82
May 98	14.01	18.60	12.08	17.39
Jun 98	16.72	23.08	14.77	21.91
Jul 97	19.25	26.93	17.09	25.90
Aug 97	19.42	25.25	18.12	24.72
Sep 97	17.72	22.17	17.43	22.15
Oct 97	13.86	15.99	14.89	16.81
Nov 97	8.42	7.76	10.40	9.20
Dec 97	4.47	3.59	6.39	4.85
Annual Mean	11.41	14.40	11.27	14.40
MST	18.46	25.09	16.66	24.18
MWT	4.14	4.16	5.37	4.95
MST - MWT	14.32	20.93	11.29	19.22

Table 3. Monthly Temperature Averages for Two Sites in Latourette Park.

Month	Woods 10 cm (C)	Landfill 10 cm (C)	Landfill 50 cm (C)	Woods Air (C)	Landfill Air (C)
Jan 98	5.56	4.57	13.00	4.45	9.56
Feb 98	5.17	8.68	21.84	4.51	9.80
Mar 98	6.69	13.47	24.84	7.10	9.39
Apr 98	10.74	14.89	24.63	11.65	11.81
May 98	14.23	17.87	26.69	16.36	19.28
Jun 98	16.81	30.93	28.44	18.93	20.27
Jul 97	19.55	30.64	30.63	22.91	24.95
Aug 97	19.46	25.15	29.08	21.11	21.81
Sep 97	17.87	20.81	26.38	18.11	18.32
Oct 97	13.82	14.34	22.99	12.74	14.84
Nov 97	9.08	7.64	16.89	6.51	10.20
Dec 97	5.49	4.13	13.71	3.23	5.67
Annual Mean	12.04	16.09	23.26	12.30	14.66
MST	18.60	28.91	29.38	20.98	22.34
MWT	5.40	5.79	16.18	4.06	8.34
MST-MWT	13.20	23.11	13.20	16.92	14.00

Results

Central Park

Figures 13 and 14 show the temperature signatures and Table 2 displays the monthly averages for the two sites in Central Park. The Mean Annual Soil Temperature (MAST) averaged 3.13°C (5.63°F) warmer at the playground area for the deeper depths. The differences between the Mean Summer Temperature (MST) and the Mean Winter Temperature (MWT) were greater at the playground area. These data suggest a greater difference between the MAST in adjacent ecosystems (vegetated versus unvegetated) than hypothesized.

Latourette Park

Figures 15 and 16 show the temperature signatures and Table 3 displays the monthly averages for the two sites in Latourette Park. The MAST averaged 12.04°C for the 10-cm depth in the woods versus 23.26°C for the 50-cm depth at the landfill. The MAST at the landfill is 11.22°C (20.20°F) warmer than in the adjacent woods. The differences between the Mean Summer Temperature (MST) and the Mean Winter Temperature (MWT) for the 10-cm soil depths were greater at the landfill area (23.11°C versus 13.20°C). The exothermic sources at the landfill site have dramatically increased the MAST for the 50-cm soil depth over the wooded area to the degree that the Greatkills soil has a hyperthermic soil temperature regime (Soil Survey Staff, 1996).

The mean annual air temperature was greater at the landfill area than in the adjacent woods (14.66°C versus 12.30°C). It is conjectured that excess exothermic heat rising from the landfill has mixed with the ambient air temperature to increase the monthly averages, particularly during the winter season (Table 3). This difference is not typical for adjacent vegetated versus unvegetated ecosystems. Data from a recent study in western Illinois suggests only a 0.2°C air temperature difference between natural ecosystems in close proximity where the slope and soils are similar (Mount, 1998, unpublished data).

Queens and Brooklyn

Temperature data from 1998 to 2000 for Floyd Bennett Field of Brooklyn, indicated a MAST of about 12.5°C. This is a little warmer than the forested site in Manhattan's Central Park. A 7-cm thick organic soil on top of concrete (Lithic Udifolist) averaged 10.9°C from 1999 to 2000. In Queens, a landfill site averaged 12.7°C from 1999 to 2000. Reasons why this landfill did not exhibit exothermic activity are thought to reside in the depth of surface soil material covering the landfill depositions.

Conclusions

Urban activities in New York City have increased the MAST. The unvegetated playground in Central Park is 3.13°C (5.63°F) warmer than an adjacent wooded area. The MAST of the Greatkills soil in the 60-year-old landfill area on Latourette Park is impacted by exothermic activity. The MAST for the Greatkills soil is 11.22°C (20.20°F) warmer than in the adjacent woods and its soil temperature regime is HYPERTHERMIC (Soil Survey Staff, 1999). This, along with the increase of the air temperature, results in a microclimate at the landfill area of Staten Island that contributes inputs to global warming.

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Figure 10. Valois Soil Profile.

Figure 12. Greatkills Soil Profile.

Figure 11. The Greatkills Site is Vegetated with Phragmite.

Figure 13.

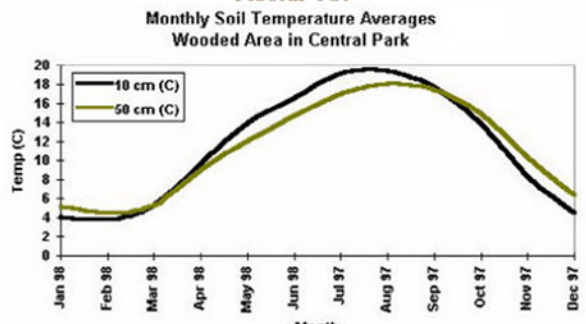


Figure 14.

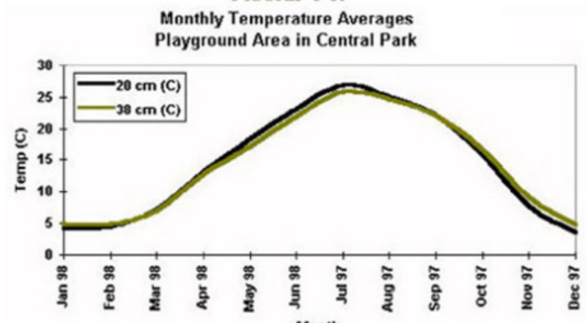


Figure 15.

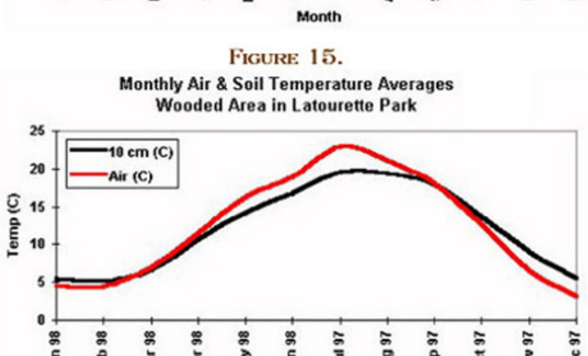
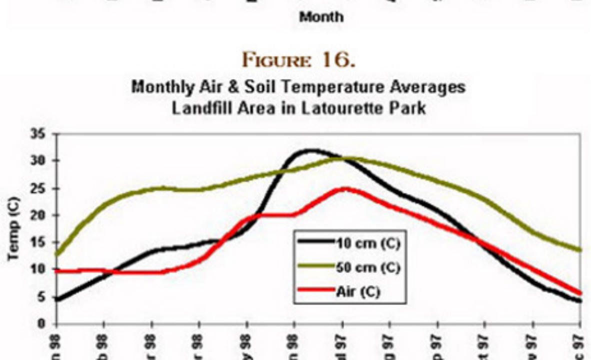


Figure 16.



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